United States Environmental Protection Agency **Office of Research and Development**

National Exposure Research Laboratory
Research Abstract

Government Performance Results Act (GPRA) Goal 1
Annual Performance Measure 224

Significant Research Findings:

Human Exposure and Dose Modeling for Benzene: An Urban Area Case-Study

Scientific Problem and Policy Issues

Conducting National Air Toxics Assessments (NATA) is one of four components in EPA's risk-based National Air Toxics Program, and includes all of the exposure and risk assessment activities. NATA activities provide air toxics exposure and risk assessments for both stationary and mobile sources, and relative risks from indoor air exposures. To improve the scientific basis of exposure and risk assessments, models that better characterize the relationship between concentrations measured at central site monitors and residential, vehicular, and other micro-environmental exposures need to be developed. These models can then be used to estimate the range of potential chemical exposure across the general population as well as susceptible and highly-exposed subpopulations.

Research Approach

EPA's National Exposure Research Laboratory (NERL) has developed a human exposure model to estimate population exposures to air toxics. The Stochastic Human Exposure and Dose Simulation Model for Air Toxics (SHEDS-AirToxics) uses a probabilistic approach to estimate the distribution of inhalation, ingestion, and dermal exposure and absorbed dose for a user-specified population. The model framework was developed around a benzene exposure case study, and an application of the model to estimate benzene exposures was conducted for the population of Houston, Texas. SHEDS-AirToxics estimates an individual's exposure to benzene in several specific micro-environments (e.g., indoors at home, in vehicles, outdoors) using ambient benzene concentrations, sources specific to the microenvironment, and exposure factors. Inhaled dose is estimated from the micro-environmental exposure concentrations (all using hourly ambient concentration data) and activity-level-specific breathing rates. The model includes advanced exposure algorithms specific to mobile source pollutants and activities. For indoor environments, passive exposure to cigarette smoke and exposure to benzene intruding from attached garages are also included, whenever appropriate. In addition to inhalation, potential exposures from other routes and pathways are considered (e.g., ingestion of benzene on food, dermal absorption from benzene while bathing with contaminated water, and accidental fuel spillage while refueling).

Results and Impact	SHEDS-AirToxics model results show that absorbed dose was dominated by the inhalation route (about 93%, on average), followed by the dietary route (7%), with negligible amount from the dermal route (<1%). For the inhalation route of exposure, the bulk of the annual average absorbed dose for much of the population was from indoor home exposures (on average 40%), followed by exposure inside vehicles while driving (on average 15%), and exposure during refueling automobiles (about 15%). The relative contribution of the various micro-environments was dependent on the time spent in each micro-environment and on the exposure levels estimated from the exposure scenarios for each micro-environment. The model provides independent estimates of population exposures to air toxics in support of EPA's research programs in human exposure, human health effects, and source emissions characterization. This model allows EPA's Office of Air and Radiation, Regional Offices, and State agencies to improve their mobile source and urban air toxics exposure assessments. The model not only provides improved human exposure estimates to air toxics, but points to parameters where additional research is needed to reduce the uncertainty in exposure assessments.
Research Collaboration and Research Products	ManTech Environmental Technology, Inc. collected and analyzed the data and developed the model algorithms. Examples of recent publications from this study include the following: C Stallings, SE Graham, G Glen, L Smith. 2003. SHEDS-AirToxics Users and Technical Guide. EPA/600/C-03/003. Graham SE and JM Burke. 2003. "Microenvironmental exposures to benzene: a critical review and probabilistic model input distribution development." EPA/600/J-03/008. Graham SE and McCurdy. 2004. "Developing meaningful cohorts for human exposure modeling. Journal of Exposure Analysis and Environmental Epidemiology. 14(1)23-43.
Future Research	NERL is further developing the model to include a wide range of individual air toxics and mixtures of compounds. Additional chemicals associated with mobile sources are being addressed first (e.g., toluene, ethyl benzene, xylenes), followed by pollutants that have significant pathways of exposure other than inhalation (e.g., arsenic). Current research also involves extending the ventilation estimation algorithm to reflect air toxic specific dosimetry. NERL will evaluate inhalation dose for several air toxics. In addition, NERL will incorporate or link local source and/or emission models to SHEDS-AirToxics, focusing on indoor sources and chemicals such as those emitted from furniture and paints.
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